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Watson et al.

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(54) **METHOD AND SYSTEM OF SAND MANAGEMENT**

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E21B 43/04	(2006.01)
E21B 34/06	(2006.01)

(52) **U.S. Cl.**

CPC ***E21B 43/04*** (2013.01); ***E21B 34/06*** (2013.01); ***E21B 43/14*** (2013.01)

(58) **Field of Classification Search**

CPC E21B 43/14; E21B 43/04

USPC 166/51, 278, 276

See application file for complete search history.

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(57) **ABSTRACT**

A technique facilitates sand control in a wellbore. A lower completion and an upper completion are run downhole into the wellbore and deployed. The lower completion assembly employs a plurality of packers to isolate well zones. The lower completion assembly also has gravel pack ports which are independently opened to enable gravel packing of each individual zone via a tool run downhole. Additionally, the lower completion assembly has a production port in each zone. A shifting tool is employed to open the production ports and to enable production from the well zones.

11 Claims, 5 Drawing Sheets

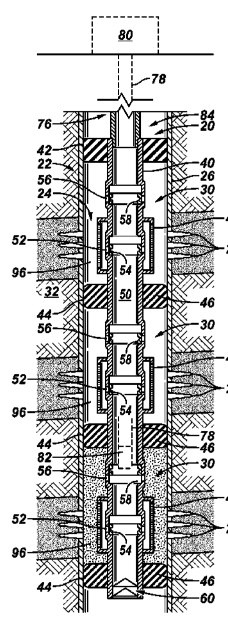
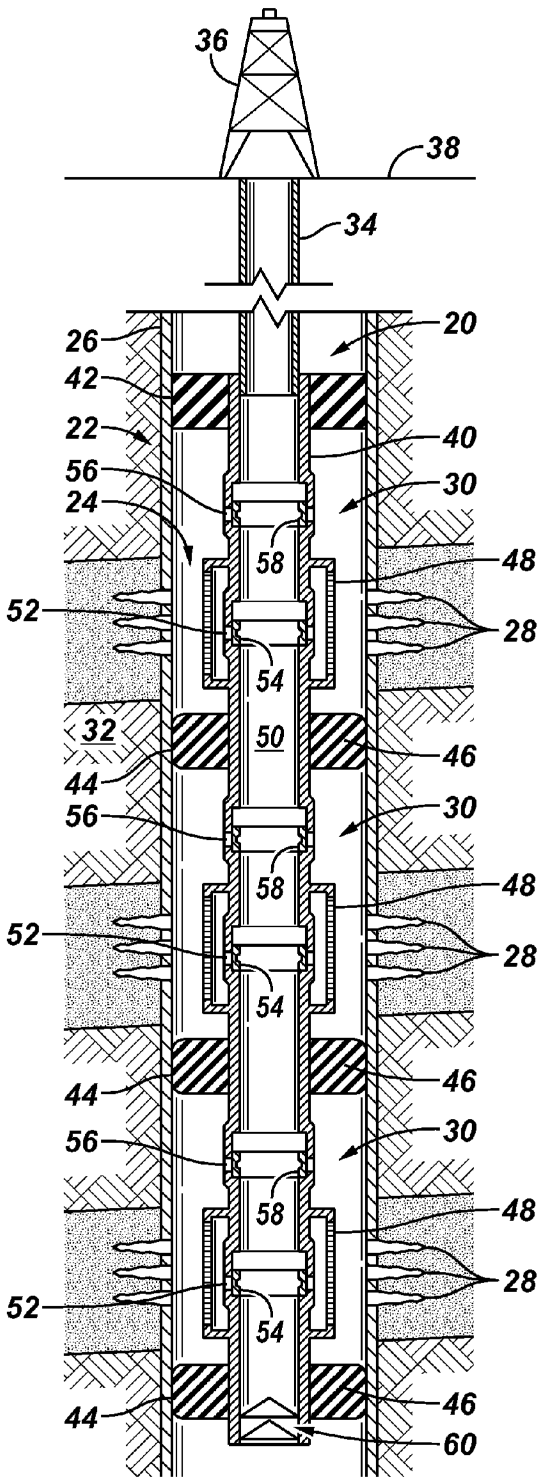


FIG. 1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44
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54
44
46
60

FIG. 2

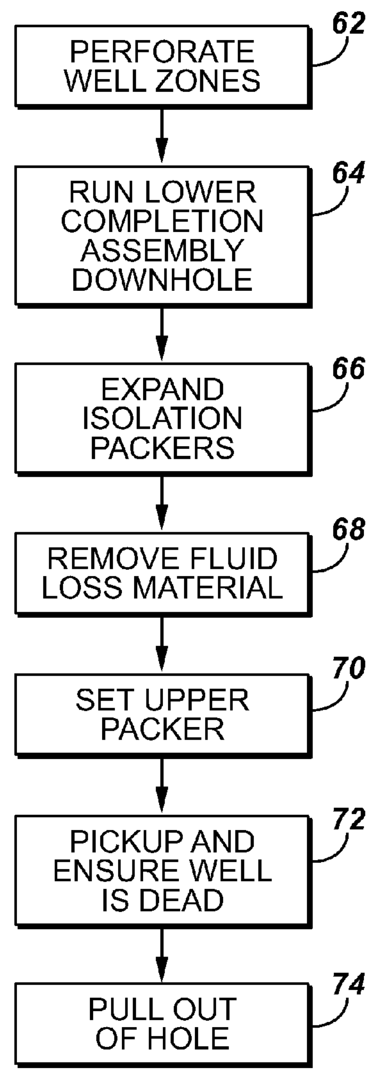
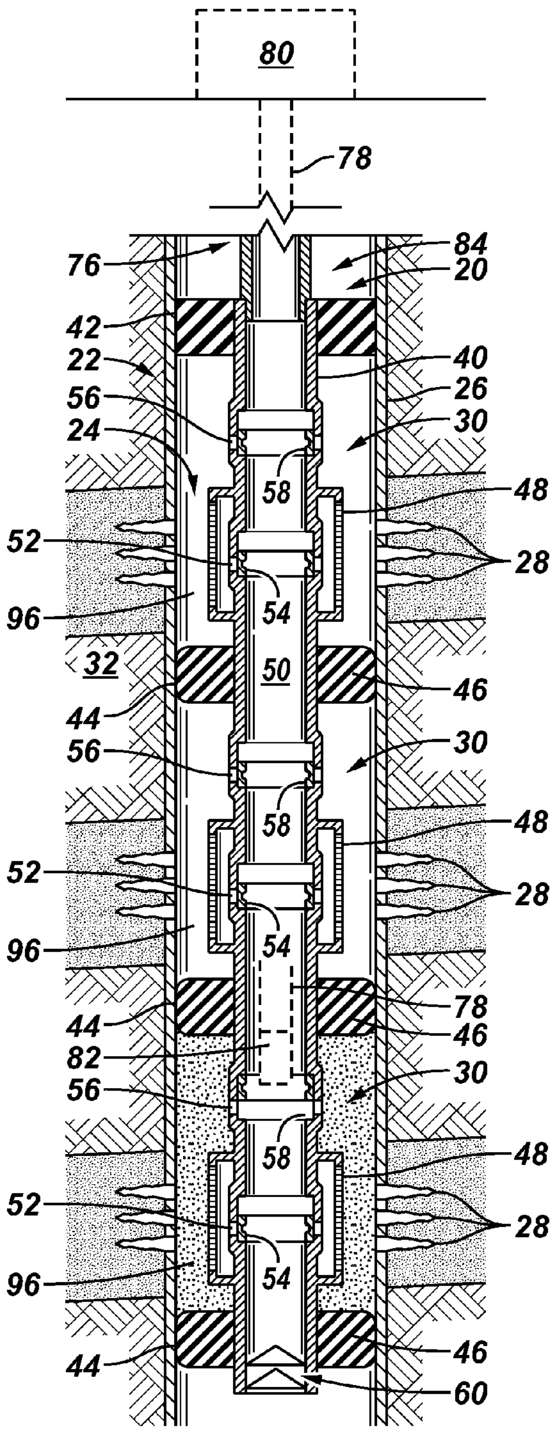

PERFORATE WELL ZONES
62
RUN LOWER COMPLETION ASSEMBLY DOWNHOLE
64
EXPAND ISOLATION PACKERS
66
REMOVE FLUID LOSS MATERIAL
68
SET UPPER PACKER
70
PICKUP AND ENSURE WELL IS DEAD
72
PULL OUT OF HOLE
74

FIG. 3


80
78
84
76
20
42
40
22
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56
30
24
58
48
52
28
54
96
32
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44
46
82
60

FIG. 4

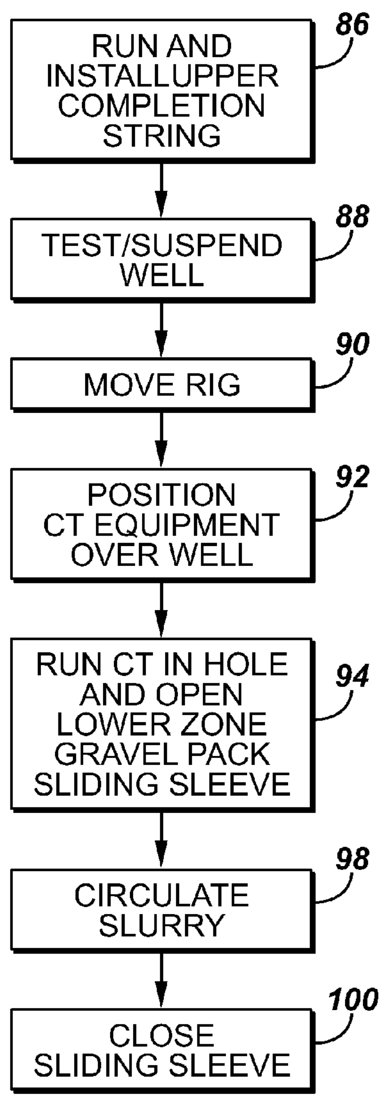
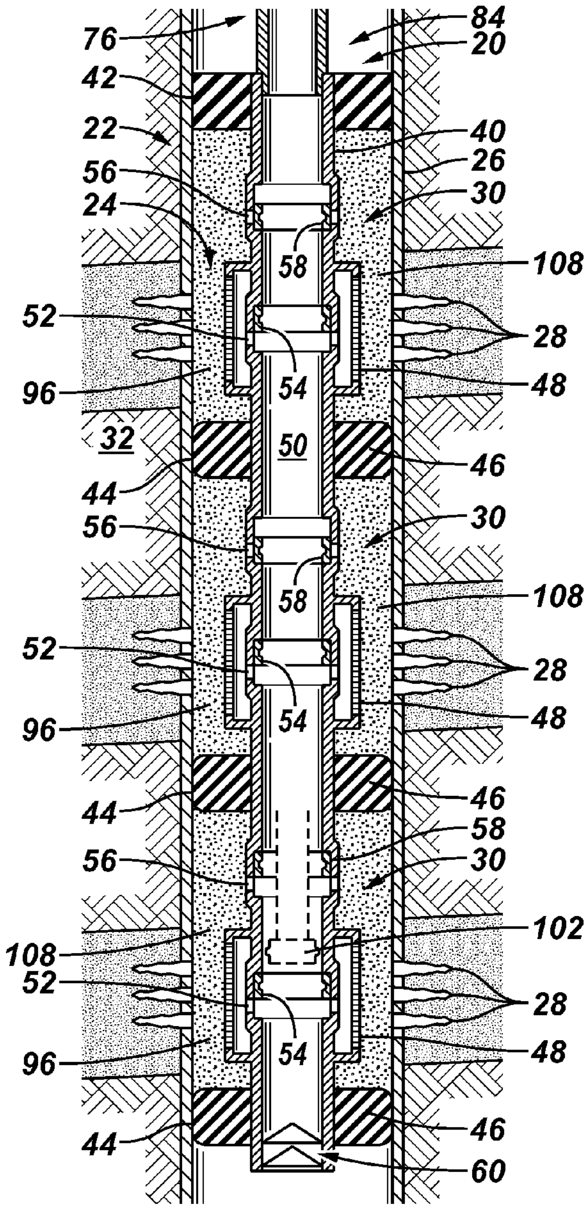

RUN AND INSTALLUPPER COMPLETION STRING
86
TEST/SUSPEND WELL
88
MOVE RIG
90
POSITION CT EQUIPMENT OVER WELL
92
RUN CT IN HOLE AND OPEN LOWER ZONE GRAVEL PACK SLIDING SLEEVE
94
CIRCULATE SLURRY
98
CLOSE SLIDING SLEEVE
100

FIG. 5


76
84
20
42
22
40
26
56
30
24
58
108
52
28
54
96
48
32
50
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46
56
30
58
108
52
28
54
96
48
44
46
58
56
30
102
108
52
28
54
96
48
44
46
60

FIG. 6

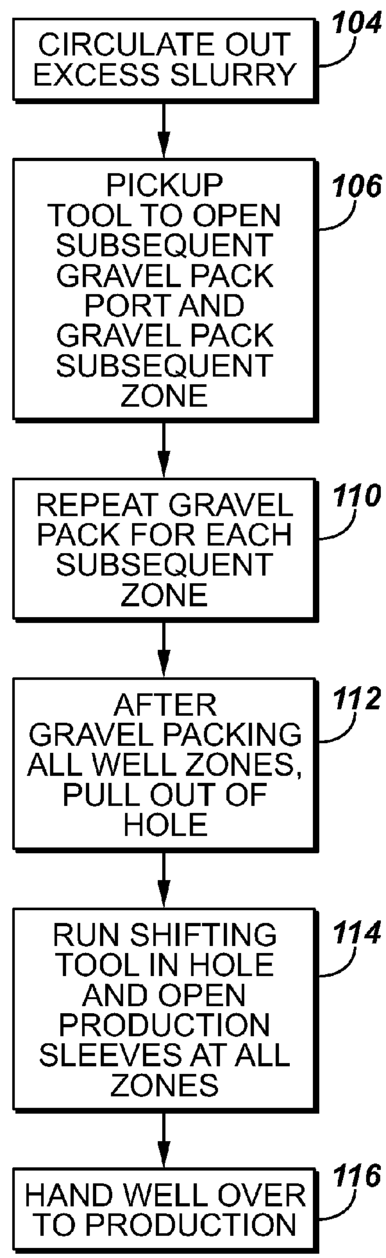
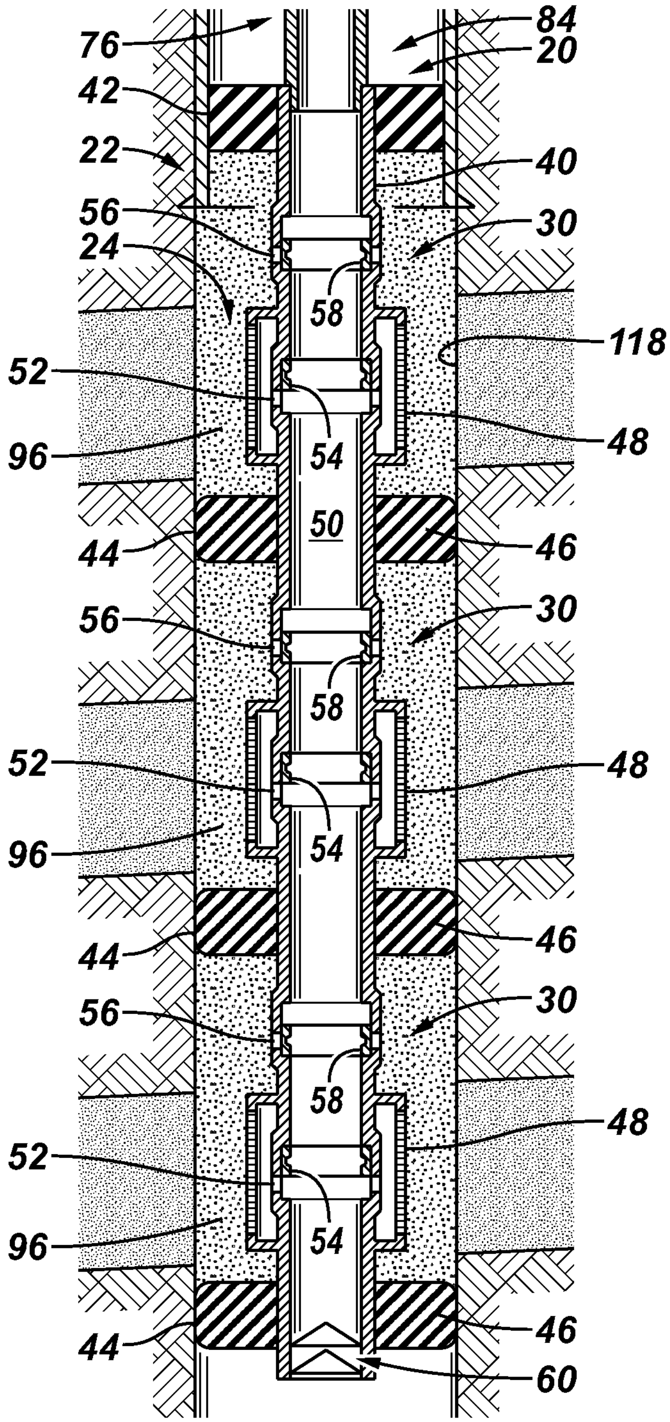

CIRCULATE OUT EXCESS SLURRY
104
PICKUP TOOL TO OPEN SUBSEQUENT GRAVEL PACK PORT AND GRAVEL PACK SUBSEQUENT ZONE
106
REPEAT GRAVEL PACK FOR EACH SUBSEQUENT ZONE
110
AFTER GRAVEL PACKING ALL WELL ZONES, PULL OUT OF HOLE
112
RUN SHIFTING TOOL IN HOLE AND OPEN PRODUCTION SLEEVES AT ALL ZONES
114
HAND WELL OVER TO PRODUCTION
116

FIG. 7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84
20
42
22
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56
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24
58
118
52
48
96
54
50
44
46
56
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56
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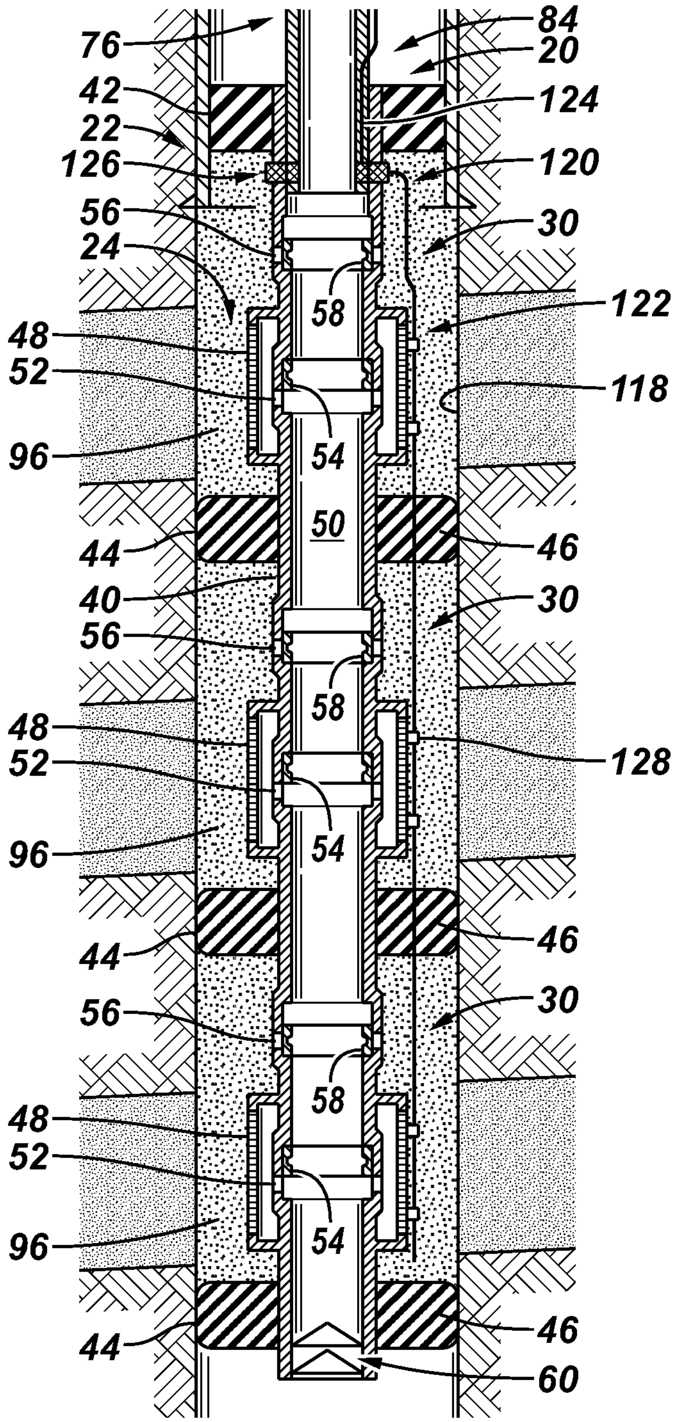
96
44
46
60

FIG. 8


76
84
20
42
124
22
126
120
56
30
24
58
122
48
52
118
54
96
50
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46
40
30
56
58
48
128
52
54
96
44
46
56
30
58
48
52
54
96
44
46
60

METHOD AND SYSTEM OF SAND MANAGEMENT

CROSS-REFERENCE TO RELATED APPLICATION

The present document is based on and claims priority to U.S. Provisional Application Ser. No. 61/181,526, filed May 27, 2009.

BACKGROUND

In many well applications, various completions and completion techniques are employed to limit the influx of sand from the surrounding formation. Many types of completions have been designed to inhibit or block the migration of sand into downhole equipment in an effort to avoid damage to the equipment which can otherwise result as particulate matter passes through with the production fluid. A variety of sand screens and/or gravel packs may be employed to control the sand production. However, current equipment and techniques can be relatively complex, burdensome and expensive to employ.

SUMMARY

In general, the present invention provides a technique for providing sand control in a wellbore. A lower completion is run downhole into the wellbore engaged with, or subsequently engaged with, an upper completion. The lower completion assembly employs a plurality of packers to isolate well zones. Gravel pack ports are independently opened to enable gravel packing of each individual zone via a coil tubing string or other small diameter tubing string run downhole. Subsequently, a separate shifting tool is employed to open production ports which enable production from the isolated well zones.

BRIEF DESCRIPTION OF THE DRAWINGS

Certain embodiments of the invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

FIG. **1** is an illustration of a sand control system employed in a wellbore, according to an embodiment of the present invention;

FIG. **2** is a flowchart illustrating an example of a sand control procedure, according to an embodiment of the present invention;

FIG. **3** is an illustration of the sand control system during another stage of operation, according to an embodiment of the present invention;

FIG. **4** is a flowchart illustrating an example of another sand control procedure, according to an embodiment of the present invention;

FIG. **5** is an illustration of the sand control system during another stage of operation, according to an embodiment of the present invention;

FIG. **6** is a flowchart illustrating an example of another sand control procedure, according to an embodiment of the present invention;

FIG. **7** is an illustration of an alternate example of a sand control system, according to an embodiment of the present invention; and

FIG. **8** is an illustration of another alternate example of a sand control system, according to an embodiment of the present invention.

DETAILED DESCRIPTION

In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those of ordinary skill in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

The present invention generally relates to a method and system for controlling sand in a well application. According to one embodiment, the method and system enable a simplified approach to providing a completion assembly in a wellbore with protection against the influx of sand from the surrounding formation. The technique enables deployment of a lower completion assembly and also an upper completion string. In many applications, the lower completion assembly and the upper completion string are deployed downhole together in a single trip for a one trip installation. However, the technique may be adapted to deploy the lower completion assembly in a first run in hole and the upper completion string in a subsequent run.

The present technique enables the wellbore to be segregated into a plurality of well zones which facilitate production of fluid from a plurality of corresponding well zones in the surrounding formation. Each of the well zones along the wellbore may be individually gravel packed to help limit the flow of sand into the lower completion assembly. The technique provides a simple approach to gravel packing independent zones and subsequently opening the zones to production of a desired well fluid. Additionally, the technique provides the ability to employ a non-service tool, non-sealbore gravel packing system.

Referring generally to FIG. **1**, an embodiment of a sand control system comprises a lower completion assembly **20** which is illustrated as deployed in a well **22**. The well **22** is defined by a wellbore **24** which, in this example, has been lined with a liner or casing **26**. A plurality of perforations **28** has been formed through the casing **26** in each of a plurality of well zones **30**. The perforations **28** enable flow of a production fluid, e.g. a hydrocarbon based fluid, from a surrounding formation **32** into the wellbore **24**.

The lower completion assembly **20** is run in hole to a desired location within wellbore **24** to enable retrieval of the production fluid from the desired reservoir within formation **32**. A conveyance **34** is employed to convey the lower completion assembly **20** to the desired location within wellbore **24**. Depending on the environment and application, conveyance **34** may comprise a variety of tubing types, cables, or other suitable conveyances. In the embodiment illustrated, a rig **36** is positioned at a surface location **38** to deploy lower completion assembly **20** downhole via conveyance **34**. It should be noted the present technique enables deployment of the lower completion assembly **20** and an upper completion assembly (described below) in a single trip to facilitate an efficient, one trip installation. Thus, in many applications the lower and upper completions are deployed together, and description of the lower completion assembly herein does not imply a two trip installation technique. However, certain environments and/or types of completion equipment may be amenable to a two trip installation.

In the embodiment illustrated in FIG. **1**, the lower completion assembly **20** comprises a completion tubular **40** to which an upper packer **42** is mounted. By way of example, the upper packer **42** may comprise a Quantum packer available from Schlumberger Corporation. Additionally, a plurality of isolation packers **44** is positioned along the tubular **40** to enable isolation of the well zones **30** along wellbore **24**. The isolation packers **44** may comprise a variety of devices able to seal off the annulus between tubular **40** and the surrounding casing **26**. According to one embodiment, however, isolation packers **44** are constructed as swellable packers formed with a swellable material **46** which swells in the presence of a specific substance. For example, the swellable material **46** may be designed to swell and expand against the surrounding wellbore wall when exposed to a specific fluid, e.g. diesel fluid, or another fluid designed to cause swelling and expansion of the material **46**. In some applications, however, packers **44** may comprise mechanical packers.

The lower completion assembly **20** also may comprise a plurality of screens **48**, such as manifold screens, designed to further prevent movement of undesired particulate matter into an interior **50** of completion tubular **40**. Radially inward from each screen **48**, the lower completion assembly **20** further comprises one or more production ports **52** which may be selectively opened and closed via a corresponding production sliding sleeve **54**, or other suitable flow control device. The sliding sleeves **54** enable selective control over the inflow of production fluid through the corresponding screen **48** and into interior **50** of lower completion assembly **20**.

In the embodiment illustrated, the lower completion assembly **20** further comprises a plurality of gravel pack ports **56** with at least one gravel pack port **56** extending through completion tubular **40** in each well zone **30**. The gravel pack port or ports **56** of each well zone **30** may be positioned above the production ports **52** and screen **48** within that well zone **30**. Flow through the gravel pack ports **56** is controlled by corresponding gravel pack sliding sleeves **58**, or other suitable flow control devices, to control the outflow of slurry into the surrounding annular region.

Depending on the specific application, lower completion assembly **20** may further comprise a valve mechanism **60** positioned in interior **50** of tubular **40** at a lower end of lower completion assembly **20**. The valve mechanism **60** may be employed to control flow along interior **50** by, for example, restricting flow past lower completion assembly **20** to a single flow direction. By way of example, valve mechanism **60** may comprise a double poppet shoe or a check valve.

With additional reference to the flow chart of FIG. **2**, one example of an initial sand control procedure utilizing lower completion assembly **20** is illustrated. In this example, a perforating procedure is initially carried out to perforate each well zone **30** with perforations **28**, as represented by block **62**. Subsequently, the lower completion assembly **20** is run downhole into wellbore **24** via rig **36**, as represented by block **64**. Once the lower completion assembly is positioned at the desired setting depth within wellbore **24**, the isolation packers **44** are expanded against the surrounding wellbore wall, as represented by block **66**. According to at least one embodiment, expansion of the isolation packers **44** is achieved by displacing an activating fluid through a service tool to expand the isolation packers by swelling the swellable material **46**. The activating fluid flowed downhole also may be used to remove fluid loss material, e.g. fluid loss pills, deployed over the perforations **28**, as represented by block **68**.

The upper packer **42** may then be set, as represented by block **70**. By way of example, upper packer **42** may be set by dropping a setting ball down through conveyance **34**; however other mechanisms also may be used to set the upper packer **42** against the surrounding wellbore wall. Subsequently, the rig **36** is employed to pickup the service tool and to reverse the activating fluid flow, if activating fluid has been deployed downhole. At this stage, the operator also ensures that the well is dead by, for example, inflow testing if necessary, as represented by block **72**. The conveyance **34** and service tool, if deployed, are then pulled out of hole, as represented by block **74**.

Referring generally to FIG. **3**, an upper completion string **76** is illustrated as deployed downhole into engagement with lower completion assembly **20**. As described above, the upper completion **76** and the lower completion **20** often are joined before run in and then run in hole in a single trip. The upper completion string **76** may be engaged within the upper end of lower completion assembly **20** via a variety of available engagement mechanisms and techniques. Once the upper completion string **76** and lower completion assembly **20** are positioned in the wellbore, coil tubing **78** may be deployed downhole through upper completion string **76** into lower completion assembly **20** via surface based coil tubing equipment **80**. The coil tubing **78** can be used to manipulate a variety of coil tubing tools **82** within lower completion assembly **20**. It should be noted that upper completion string **76** is combined with lower completion assembly **20** to form an overall sand control system **84**. In some applications, coil tubing string **78** may be replaced by a small diameter, through-tubing jointed pipe. Additionally, the coil tubing equipment **80** may comprise a coiled tubing barge which allows the completion deployment rig **36** to be moved off location. In many applications, movement of the rig **36** off the wellbore to enable use of the coil tubing barge or other coil tubing equipment **80** substantially increases operational efficiency and provides great financial benefit with respect to the gravel packing operation.

With additional reference to the flow chart of FIG. **4**, an example of a subsequent sand control procedure utilizing lower completion assembly **20** is illustrated. In this example, the upper completion string **76** is run and installed downhole, as represented by block **86**. The well is then tested and suspended, as represented by block **88**. This allows the rig **36** to be moved off location, as represented by block **90**. During movement of the rig off location, swell packers **44** may be allowed to activate, i.e. swell. (In other applications, however, the packers **44**, e.g. mechanical packers, are set prior to leaving location with the main rig **36**.) Subsequently, coil tubing equipment **80** is moved over well **22** and positioned for deploying coil tubing **78** downhole, as represented by block **92**.

Once the coil tubing equipment **80** is in place, coil tubing **78** is run in hole and coil tubing tool **82** is used to move the gravel pack sliding sleeve **58** and to open the corresponding gravel pack port **56** of the lowermost well zone **30** instead of using an internal service tool, as represented by block **94**. Slurry is then directed downhole through the coil tubing **78**, out through coil tubing tool **82**, and then through the lowermost gravel pack port **56**. The slurry is circulated through an annular region **96** surrounding the lower completion assembly **20** in the lowermost well zone **30** (see FIG. **3**), as represented by block **98**. In this embodiment, the slurry may then be squeezed, as opposed to circulated, across the lowermost perforations **28**. Subsequently, the lowermost gravel pack sliding sleeve **58** is closed via coil tubing tool **82**, as represented by block **100**.

Referring to FIGS. **5** and **6**, a subsequent procedure of the overall sand control technique is illustrated. As illustrated in FIG. **5**, a shifting tool **102** may be employed within lower completion assembly **20** to facilitate preparation of the well **22** for production. Referring to the flowchart of FIG. **6**, however, one example of a procedural approach for finalizing preparation of the well **22** for production is illustrated.

Following gravel packing of the lowermost well zone **30**, excess slurry is circulated out, as represented by block **104**.

The coiled tubing tool **82** is then picked up to open the next sequential gravel pack port **56** by moving its corresponding gravel pack sliding sleeve **58**. This allows the subsequent well zone **30** to be gravel packed by squeezing slurry across the well zone perforations, as represented by block **106**. The gravel packing procedure is repeated for each subsequent well zone **30** until each annular region **96** is filled with an appropriate gravel pack **108**, as represented by block **110**.

Once the gravel packing procedure is completed at each well zone **30** and a gravel pack **108** is disposed in each annular region **96**, the coil tubing tool **82** is pulled out of hole, as represented by block **112**. After removing coil tubing tool **82**, the shifting tool **102** is run in hole on, for example, coil tubing **78** deployed by coil tubing equipment **80**. The shifting tool **102** is used to open all of the production ports **52** by moving the corresponding production port sliding sleeves **54**, as represented by block **114**. After opening the production ports **52** to enable the inflow of production fluid, e.g. oil, the well **22** is ready for production, as represented by block **116**. Within each well zone **30**, the gravel pack **108** and screen **48** cooperate to provide sand control by restricting the influx of sand into interior **50** of lower completion assembly **20**. The design of lower completion assembly **20** provides an easy and effective system and procedure for controlling the influx of sand.

Referring generally to FIG. **7**, another example of the overall sand control system **84** is illustrated. In this embodiment, the lower completion assembly **20** and upper completion **76** are deployed in an open hole wellbore. The isolation packers **44** are then expanded against a surrounding open wellbore wall **118** rather than against a surrounding wellbore wall formed of casing **26**. In this example, the isolation packers **44** also may be formed as swellable isolation packers, although other types of expandable packers, e.g. mechanical packers, may be used to seal off regions of wellbore **24** within the open wellbore wall **118**. In this embodiment, the same types of procedures as described above with reference to FIGS. **1-6** may be employed to gravel pack each annular region **96** and to prepare the well for production. With respect to at least some open hole applications, an additional shroud may be placed around each gravel pack port **56** to avoid slurry dehydration back into the wellbore.

In another embodiment, the overall sand control system **84** is designed with sandface monitoring capabilities. As illustrated in the embodiment of FIG. **8**, a sandface monitoring system **120** may be deployed along lower completion assembly **20**. Although sandface monitoring system **120** may comprise a variety of sensors and other components, one example utilizes a sensor system **122** deployed along an exterior of completion tubular **40**. The sensor system **122** is coupled with a communication line **124** via an appropriate coupler mechanism **126**. In this example, communication line **124** is routed up along upper completion string **76** to a surface location. The coupler mechanism **126** is adapted according to the specific sensor system employed, however one example comprises an electro-inductive coupler.

In the example illustrated, sensor system **122** may comprise a suitable sensor **128**, such as a fiber optic sensor or sensor gauges. Regardless, the sensor or sensors **128** may be used to monitor desired parameters across the sandface, such as temperature, pressure and flow. Depending on the specific design of sensor system **122**, the sandface monitoring system **120** may be run in one trip for ease of installation; or sections of the sandface monitoring system **120** may be joined downhole. When a fiber-optic sensor is employed, the optical fiber may be pumped down through a corresponding tube to avoid the need for a coupler mechanism **126**. However, a substantial variety of deployment techniques may be used to accommodate a wide range of sensors, coupler mechanisms, and other potential components of the sandface monitoring system **120**.

The system and technique described above demonstrate a simple approach to sand control in a well. However, a variety of adaptations and adjustments may be made to accommodate a variety of well environments. For example, the lower completion assembly **20** may be run in hole with coil tubing, jointed pipe, or other suitable conveyance techniques. Additionally, the lower completion assembly **20** and upper completion **76** may be run in hole in a single trip. The sandface monitoring system **120** also may be run in hole with the lower completion assembly **20** or with the combined lower completion assembly **20** and upper completion **76**.

Furthermore, the upper packer **42** may comprise a hydraulically set open hole packer or a cased hole packer set by a dropped ball or other mechanism. The well zones **30** may be gravel packed and/or frac-packed. Additionally, the lower completion assembly **20** enables selective production from individual well zones **30** and also selective injection to individual well zones **30**. With the overall simplified system, no seal bores are required to enable the gravel packing or frac-packing procedures described above. In some applications, a live annulus is possible to enable real-time monitoring of downhole treatment pressure without friction effects otherwise resulting from surface pumping through tubing/coil tubing. The overall sand control system **84** also is suitable for rigless well treatments with coil tubing and/or treatments employing a rig and jointed pipe.

When valve mechanism **60** is employed, a check valve or double poppet washdown shoe allows displacement of underbalance packer swelling fluids while still enabling well control. If well zones **30** are to be treated with a consolidated treatment for sand control, the screens **48** may be replaced with sliding sleeves. In this type of application, the top sliding sleeve may be opened and used to consolidate; and then the top sliding sleeve is closed so the lower sleeves can be used for production or injection as required. Additionally, a variety of activating fluids may be pumped down to swell the isolation packers **44** and/or break down the fluid loss pills/material placed across the perforations **28** following the perforating portion of the overall sand control procedure. Depending on the parameters of a given application, various portions of the procedure discussed above may be interchanged or eliminated. For example, the upper completion may be run before or after the gravel pack treatment is completed.

Although only a few embodiments of the present invention have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this invention. Accordingly, such modifications are intended to be included within the scope of this invention as defined in the claims.

What is claimed is:

1. A method of preparing a sand control system, comprising:

a) running a lower completion and an upper completion downhole into a wellbore in a single trip via a rig;

b) expanding a plurality of packers, of the lower completion, against the surrounding wellbore wall to create a plurality of well zones;

c) moving the rig off the wellbore;

d) after moving the rig, positioning coil tubing equipment over the wellbore;

e) after moving the rig, deploying coil tubing with a coil tubing tool through the wellbore to open a gravel pack sliding sleeve, of the lower completion, within a well zone;

f) squeezing slurry into the well zone;

g) closing the gravel pack sliding sleeve with the coil tubing tool by moving the coil tubing;

h) circulating out excess slurry;

i) picking up the coil tubing tool and opening a next sequential gravel pack sliding sleeve;

j) repeating elements e, f, g and h for each additional well zone of the plurality of well zones;

k) maintaining the coil tubing in the wellbore while gravel packing the well zones;

l) after repeating elements e, f, g and h for all well zones, pulling the coil tubing and the coiled tubing tool out of the wellbore; and

m) subsequently opening all production sleeves of the lower completion with a shifting tool run on coil tubing.

2. The method as recited in claim **1**, wherein expanding comprises swelling a plurality of isolation packers.

3. The method as recited in claim **1**, further comprising perforating all well zones of the plurality of well zones prior to running the lower completion downhole.

4. The method as recited in claim **3**, further comprising removing fluid loss material from the perforations.

5. The method as recited in claim **1**, wherein expanding comprises expanding mechanical packers.

6. The method as recited in claim **1**, wherein opening comprises opening all production sleeves with a coil tubing shifting tool.

7. The method as recited in claim **1**, wherein deploying comprises using a surface coil tubing barge.

8. The method as recited in claim **1**, wherein opening comprises opening all production sleeves with the shifting tool run in hole in a separate run.

9. The method as recited in claim **1**, wherein running comprises running the lower completion into a cased wellbore.

10. The method as recited in claim **1**, wherein running comprises running the lower completion into an open wellbore.

11. The method as recited in claim **1**, further comprising employing a sandface monitoring system with the lower completion.

* * * * *